



European  
Commission



# Towards low carbon transport in Europe

COMMUNICATING TRANSPORT RESEARCH AND INNOVATION

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Transport



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# Preface

The European Commission is pleased to present 'Towards low carbon transport in Europe'. This brochure links strategic targets in EU policy with research and innovation on decarbonising transport.

As stated in the Transport White Paper (2011), the challenge is to break the transport system's dependency on fossil fuels without sacrificing efficiency and compromising mobility. The target of delivering 60% reduction in greenhouse gas emissions by 2050 is unprecedentedly ambitious. It means we can no longer continue with 'business as usual'. Transport will have to use less energy and cleaner energy, and make more efficient use of modern transport infrastructure and services in reducing its environmental impact, and specifically CO<sub>2</sub> emissions.

Decarbonising the European transport system relies on far-sighted policies and a wide range of initiatives at all levels, based on substantial input from research and development. As shown in this brochure, many developments in cleaner and greener technologies have come through industry and research working closely together in public private partnerships supported with EC co-financing.

Because of the complexity of the transport system, a wide scope of policies and measures and research initiatives are needed in tackling CO<sub>2</sub> emission reduction. These range from long-term planning of modern infrastructure and services at EU, national, regional and urban level to the transport choices we make as individuals. The scope of interventions outlined in this brochure demonstrates how research and innovation (R&I) is contributing to a sustainable, low carbon transport system in Europe.



# 1 INTRODUCTION

## Transport and CO<sub>2</sub> emissions

Climate change is one of the most pressing challenges our society faces today and for the foreseeable future. The European Union acknowledges the impact of rising global temperature and is committed to reducing carbon dioxide (CO<sub>2</sub>) emissions which are the largest part of greenhouse gas emissions that cause climate change.

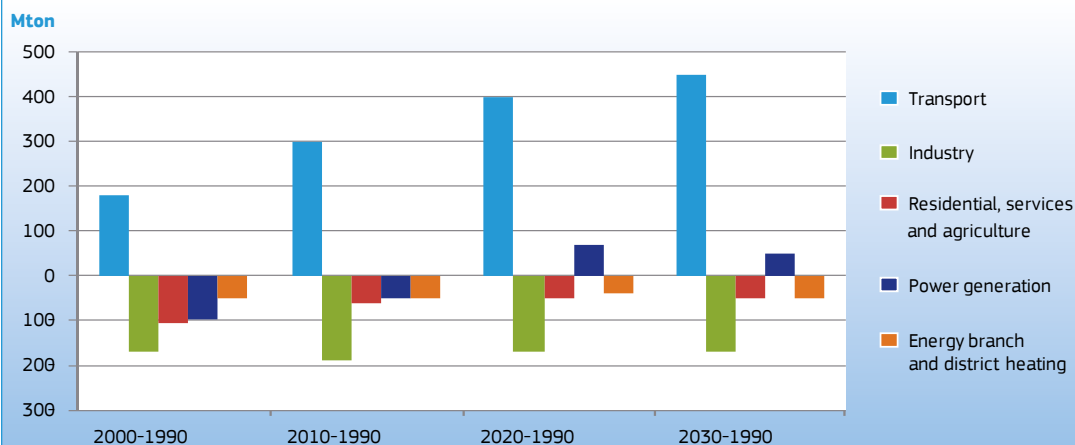
The transport sector is a major contributor to CO<sub>2</sub> emissions because of its dependency on fossil fuels in all modes. Statistics indicate that the transport sector contributes 23% of all CO<sub>2</sub> emissions in the 27 EU Member States. Despite significant efforts to reduce emissions, transport has not achieved its decarbonising targets. If this trend continues, transport is expected to contribute 50% of all CO<sub>2</sub> emissions in the EU by 2050, if not within the next two decades. An overview of historic development of CO<sub>2</sub> emissions and estimates for various sectors is shown in Figure 1. It clearly indicates the expected continuing growth of emissions from transport.

### Approach to CO<sub>2</sub> emission reduction

This brochure discusses EC policy priorities on CO<sub>2</sub> emission reduction in the transport sector and the contribution of current and future research in shaping policy. It covers the transport modes of road, rail, air and maritime, as well as cross-border, medium distance, and urban transport.

Three policy priorities and related research are considered, as can be seen on the following page.

Figure 1. Change of CO<sub>2</sub> emissions since 1990



## EU 20-20-20 TARGETS

**The EU is proactive in the international arena in contributing to agreements on CO<sub>2</sub> emission reduction, and has a commitment to 20-20-20 targets for 2020 in climate and energy policy:**

- **20%** reduction in greenhouse gas emissions on 1990 levels and 30% reduction if other developed countries make comparable reduction commitments.
- **20%** increase in renewable energy – wind, solar and biomass – of total energy production (currently 8.5%)
- **20%** reduction in energy consumption of projected 2020 levels by improving energy efficiency.

*EC, Directorate-General for Climate Action (2010a)*



**Transport efficiency** involves making transport infrastructure and services throughout Europe more efficient and thus led to reduction in CO<sub>2</sub> emissions. Such actions include better infrastructure planning and facilitating a shift from road, which depends heavily on fossil-fuelled vehicles, to more environmentally friendly rail and inland waterway transport. Efficiency in all transport modes can be increased with the wide-scale adoption of advanced information technologies (IT), such as Intelligent Transport Systems (ITS).

**Energy efficiency** requires technological advances to raise vehicle energy efficiency in terms of the ratio of distance travelled per unit of fuel consumed.

European policy and research are directed to supporting fuel efficiency regulations, to developing new technologies and engines, and to promoting the market for clean and energy-efficient road transport vehicles through, for instance, Green Public Procurement.

**Alternative fuels and propulsion systems** are based on extensive research to enable a shift from fossil fuel dependence to decarbonised transport. While research has led to a range of promising fuels and technologies to meet emission reduction targets, market uptake will require further R&I investment and other policy interventions to bring emission reduction closer to 2050 targets.





## 2 POLICY CONTEXT

# Policy and Research for low carbon transport

**Under the Kyoto Protocol, the EU signed up to stringent targets to reduce greenhouse gases — 8% reduction in CO<sub>2</sub> emissions between 2008 and 2012. To achieve these targets, some 30 measures were identified by the European Climate Change Programme (ECCP). These measures include directives on promoting the development and use of biofuels in the transport sector, on promoting electricity generation from renewable energy sources, and a framework for eco-design requirements for energy-consuming products.**

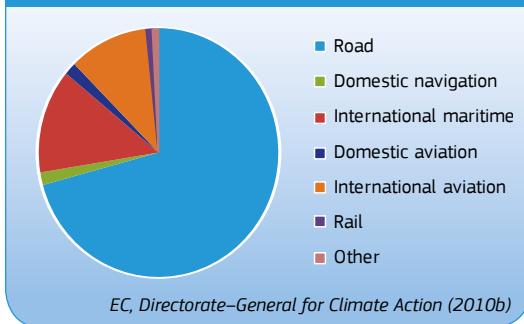
A mechanism in the European Climate Change Programme is the European Emission Trading Scheme (ETS) that requires companies in energy-intensive sectors to monitor their CO<sub>2</sub> emissions. Companies in energy-intensive sectors include power and manufacturing plants. In 2012 airlines will be added to the list. These companies are required to hold certificates that are equivalent to their respective CO<sub>2</sub> emissions. Companies that need more certificates than allocated have to trade with companies requiring fewer

certificates. The maximum number of certificates will be reduced over time in order to reduce overall CO<sub>2</sub> emissions.

Even with progress made in emission reduction in the last decade, the EU has called for more drastic reduction in greenhouse gas emissions. To create a decarbonised energy system by 2050, the European growth strategy EUROPE 2020 incorporates a flagship initiative, the 2050 Energy Roadmap (EC, 2011a). This



Figure 2. GHG emissions in the EU27 by transport mode



gives highest priority to achieving energy efficiency, stimulating use of renewable energy sources, and developing new infrastructure capacities. These improvements will have a direct impact on reducing CO<sub>2</sub> emissions in the transport sector.

Despite efforts to reduce CO<sub>2</sub> emissions from transport, increasing traffic volumes have led to increased CO<sub>2</sub> emissions from the transport sector in the past decade. A key challenge for the EU is to reverse this trend and a target has been set for 60% reduction in transport CO<sub>2</sub> emissions by 2050. As shown in Figure 2, road transport is responsible for most greenhouse gas emissions.

## Policy options

Emission reductions have to be achieved by increasing efficiency in the transport sector, improving vehicle energy efficiency and extending the use of alternative fuels and propulsion technologies. The range of policies adopted is wide and covers emission targets for new vehicles, inclusion of aviation in the European Emission Trading Scheme, targets to reduce the greenhouse gas intensity of fossil fuels, and rolling resistance limits and tyre labelling. For instance, tyres are labelled according to their energy efficiency. Reduction in their rolling resistance will contribute significantly to energy efficiency in road transport and thus to CO<sub>2</sub> emission reduction.

## Research

Research is a key component in the EU emission reduction strategy and is stimulated by EU programmes and initiatives. These include activities to improve knowledge exchange and coordination of research

activities, such as CORDIS European Community Research and Development Information Service, COST framework for European Cooperation in Science and Technology, and ERA-NET framework for research at national and regional level.

Transport research is an essential part of EU Framework Programmes, which are the main EU research and development funds. Research covers all transport modes, passenger and freight transport, as well as short, medium and long-distance transport services. A specific focus is on greening of urban transport because most people in the EU live in urban areas. Transport research projects and programmes are defined to contribute to a safer, greener and smarter transport sector.

Projects under the current Framework Programme (FP7) focus on technological development and demonstration projects. The new Framework Programme for research and innovation HORIZON 2020 (EC, 2011b) will shift the focus from product development to market entry. HORIZON 2020 will promote smart, green and integrated alternatives, with projects on improving vehicle efficiency, developing new generations of low or zero emission vehicles, and promoting alternative fuels and propulsion systems.

Given the size and complexity of CO<sub>2</sub> reduction options, no single solution is sufficient. Instead, a combination of policy initiatives and research innovations is needed to achieve the challenging targets for emission reduction. This is particularly the case in the dynamic transport sector where policy priorities to improve efficiency are drivers for reducing CO<sub>2</sub> emissions.



## 3 POLICY PRIORITY

# Towards efficient use of transport infrastructure and services

**More efficient use of transport infrastructure and services, for example by consolidating large freight volumes, has a significant impact on reducing CO<sub>2</sub> emissions. In the last decade, European transport infrastructure has ensured a high degree of mobility with continuous improvements in speed, comfort, safety and convenience. However, growing traffic volumes lead to greater congestion, increasing CO<sub>2</sub> emissions and noise hindrance, as well as to more accidents, and higher operating costs for transport operators and users.**

The expected growth for both passenger and freight transport is presented in Figure 3. Planning for more efficient use of transport infrastructure and services is a policy priority in the EU. Improved infrastructure can reduce journey distances and prevent unnecessary journeys, in both passenger and freight transport, thus alleviating congestion and cutting CO<sub>2</sub> emissions. In addition, extended use of traffic management and information systems through the application of Information and Communication Technologies (ICT) contributes to more efficient traffic flows.

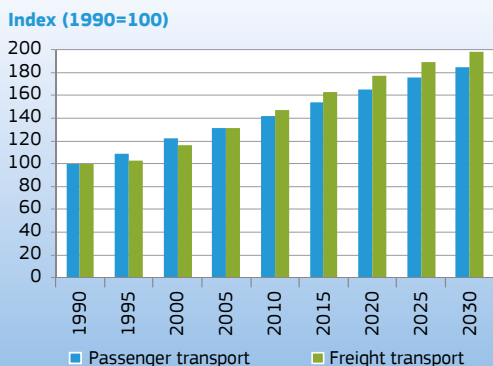
### Infrastructure planning

The Communication on Sustainable Future for Transport (EC, 2009a) stresses that new and upgraded infrastructure has to be well-planned and prioritised to optimise transport chains and networks. Integrated spatial planning will contribute to reducing or even removing transport bottlenecks, reducing congestion particularly in urban areas, and to reducing greenhouse gas emissions and harmful environmental emissions from transport. This is illustrated by Decision No 661/2010/EU of the European Parliament and of the Council of 7 July 2010 on Union Guidelines for the Development of the Trans-European Transport Network (EC, 2010).

Local and regional benefits in terms of CO<sub>2</sub> emission reduction accrue from the integration of long-term development of transport infrastructure and the implementation of sustainable urban mobility plans (SUMP).

Research has contributed in this context. Various research projects have shown that mobility policies and plans to promote public transport and stimulate environmentally friendly transport modes have led to a significant reduction in car travel per capita and in measurable CO<sub>2</sub> emission reductions. For example, the CATCH project (Carbon Aware Travel Choice) has

Figure 3. Projected growth in transport



EC, Directorate-General for Energy and Transport, 2008



demonstrated that better planning can contribute to CO<sub>2</sub> emission reduction by stimulating low carbon mode choices.

The dashboard-style presentation on CO<sub>2</sub> emissions shown in the illustration below gives a clear insight into the total emissions from transport in European cities.

In addition to effective planning of new transport infrastructure, environmental benefits are derived from more effective use of the existing network capacity and from optimising the use of each mode by removing legislative, technological and operational interoperability barriers, especially in the rail sector.

### Intelligent Transport Systems

Deployment of large scale intelligent and interoperable technologies is critical in optimising use of infrastructure capacity. Intelligent Transport Systems using Information and Communication Technologies contribute to greater efficiency of all transport modes, resulting in the reduction of CO<sub>2</sub> emissions. EU initiatives and EU-funded projects have developed smart mobility systems, including the air traffic management system of the future (SESAR), the European rail traffic management system (ERTMS) and rail information systems, maritime surveillance systems (SafeSeaNet), and River Information Services (RIS).

ITS applications in transport demand management (road charging, access management, eco-driving support and multi-modality) can also substantially reduce CO<sub>2</sub> emissions.

Progress in information technology has led to systems that can rationalise long-distance passenger journeys within the EU, enabling passengers to plan door-to-door multimodal journeys with the aid of integrated e-timetables and e-tickets. More efficient journey



planning will reduce travel times and eliminate unnecessary journeys, lowering CO<sub>2</sub> emissions.

In freight transport, information technology and transport management tools are used to optimise schedules and traffic flows (e-freight), which contribute to reduced congestion, travel time and CO<sub>2</sub> emissions. Furthermore, consolidation of large freight volumes for long-distance transport by rail and water can reduce the number and length of truck journeys, reducing CO<sub>2</sub> emissions.

Intelligent Transport Systems and Information and Communication Technologies are also important in supporting efficient use of transport infrastructure by facilitating road charging and access management schemes.

### Modal shift

A profound contribution to CO<sub>2</sub> emission reduction can be made by shifting passengers and freight to transport modes with low CO<sub>2</sub> emissions, such as rail and waterways. For freight transport, the Marco Polo Programme pursues this objective by co-funding projects that contribute to modal shift. The programme provides financial support for the start-up phase of new services and investments in innovations and knowledge transfer. The project FREIGHTWISE (see page 8) focuses on developing IT systems in integrating intermodal transport chains aiming at shifting freight from road to alternative modes.

For passenger transport, urban transport is responsible for approximately a quarter of CO<sub>2</sub> emissions. Research has shown — for example in the CIVITAS initiative — the potential for CO<sub>2</sub> reduction by shifting car trips to collective transport or to cycling.



## FREIGHTWISE

Management framework  
for intelligent intermodal  
transport

**Status:** Completed

**Total cost:** EUR 14 301 480

**EU contribution:** EUR 7 930 134

**Coordinator:** BMT BRITISH MARITIME TECHNOLOGY

**Website:** [www.freightwise.info](http://www.freightwise.info)



**FREIGHTWISE developed an IT based management tool to simplify and standardise information exchange between shippers, forwarders, and operators in an intermodal transport chain. The project demonstrated that better information exchange decreases costs and delays, making intermodal transport more competitive and economically attractive. These are strong incentives for stimulating a freight shift from road transport to more environmentally friendly transport modes. The project results contribute to EU targets for CO<sub>2</sub> emission reduction by improving management of intermodal transport.**

FREIGHTWISE is one of several EU funded projects aimed at stimulating the development and promotion of intermodal transport. For instance, SMART-CM focused on the management of container transport, INTEGRITY on information systems for door-to-door container transport, and KOMODA on development of integrated e-logistics for intermodal freight transport across Europe.

### BACKGROUND

FREIGHTWISE brought together stakeholders in intermodal transport in the EU Member States.

The project aimed to improve management of intermodal transport by facilitating information exchange between all participants in the intermodal chain. The project results were developed and tested in nine case studies covering management solutions in intermodal transport in the EU Member States. For instance, the North-West case developed management solutions for the road, rail, and maritime transport from Scandinavia to United Kingdom. The North-East case developed an information system for cross-border transport in Finland, Estonia and Russia. The Central case focused on

the integration of small and medium enterprises (SMEs) in intermodal transport.

## RESULTS

FREIGHTWISE contributed to CO<sub>2</sub> reduction by making intermodal transport more efficient and competitive. The key projects results are:

### Standardised information exchange

FREIGHTWISE established a framework to standardise information exchange between stakeholders in the intermodal transport chain. Implementation of this framework will reduce delays and costs and also improve transparency of transport operations. It offers stakeholders the option to compare prices and emissions in transport solutions, thus enabling more sustainable choices to be made.

### Communication platform for intermodal stakeholders

Increasing freight volumes in road transport together with increasing congestion, oil dependency, CO<sub>2</sub> emissions, and noise hindrance are high on the agenda. This requires greater interaction between stakeholders in the different economic sectors. The project provided European transport operators and other stakeholders with a platform to communicate sustainable,



long-term transport solutions using intermodal transport.

### Facilitating SME integration in intermodal transport

SMEs have the major share of road transport, thus contributing significantly to transport CO<sub>2</sub> emissions. FREIGHTWISE showed that the threshold for advanced IT management tools was too high for most of these companies in terms of cost and know-how. FREIGHTWISE focused on ensuring better interoperability with the SME operational systems aimed at improving integration in the intermodal transport chain and strengthening participation in environmentally friendly transport modes.



## 4 POLICY PRIORITY

# Towards more **energy efficient transport**

**Increasing energy efficiency in all transport modes will contribute to reducing CO<sub>2</sub> emissions. To this end, European policy and research aims to contribute to developing an appropriate fuel efficiency regulation, which will be set to support research on new technologies and engines, and to promote the market for clean and energy-efficient road transport vehicles.**

EU policy embraces raising vehicle energy efficiency — ratio of distance travelled per unit of fuel consumed — and rationalising transport requirements and user behaviour for more efficient movement of passengers and freight. The Europe 2020 flagship initiative 'Resource-Efficient Europe' promotes new technologies to modernise and decarbonise the transport sector.

## Fuel efficiency regulation

The longer the distance travelled per unit of fossil fuel, the more fuel-efficient the transport mode. Thus, an increase in a vehicle's fuel efficiency will reduce its CO<sub>2</sub> emissions. Fuel efficiency has been addressed through voluntary agreements with car manufacturers on CO<sub>2</sub> emissions and the mandatory labelling of cars, showing a progressive improvement in CO<sub>2</sub> emissions. Euro 5 and 6 standards for passenger cars were agreed in 2006, and come into force in 2009 and 2014, respectively.



Public and private stakeholders participating in the CARS 21 initiative (Competitive Automotive Regulatory System for the 21st Century) have developed a regulatory framework for the European automotive industry. This initiative addresses CO<sub>2</sub> emission reduction and has led to recommendations to deliver improved measurement standards for cars and light duty vehicles that take into account real life conditions, such as urban traffic.



2020 and by 10% for new heavy-duty vehicles.

Research on new technologies and engines is ongoing in almost all sectors. Current research on vehicle technology includes optimal structural solutions, as well as new design concepts for cars, ships, aircraft and locomotives, to increase energy efficiency and thus reduce CO<sub>2</sub> emissions.

The recommendations delivered by the CARS 21 initiative have been taken into account in setting the EC Regulation on emission standards for new passenger cars (EC, 2009b). In 2012, CO<sub>2</sub> emissions are limited to 130 g/km (4.5 l/100 km) for new diesel cars and 5.0 l/100 km for new petrol cars. The regulation is to be extended to CO<sub>2</sub> emission reduction for light commercial vehicles to be effective in 2016. Figure 4 presents the development of the share of CO<sub>2</sub> emission categories of new cars sold in Europe.

### Research on new technologies and engines

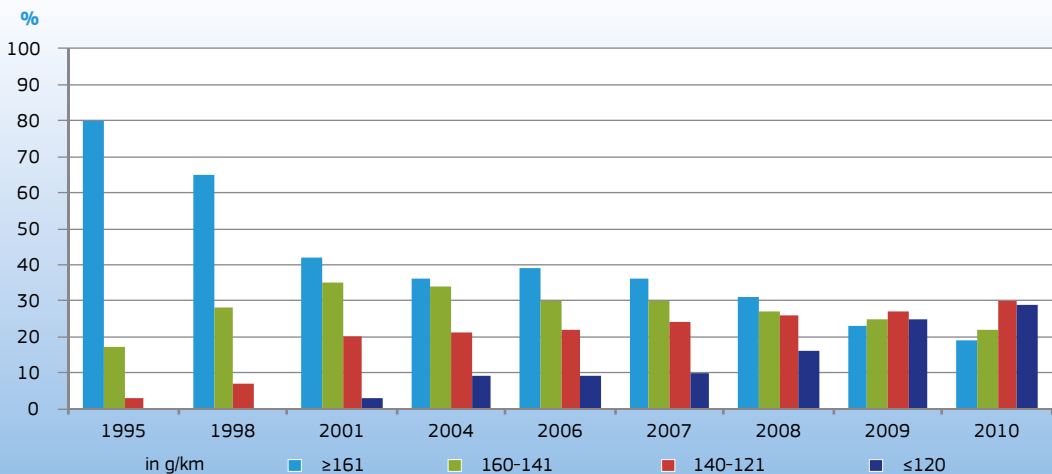
EU funded research is developing technologies that will enable a further 40% reduction in CO<sub>2</sub> emissions from new passenger cars and light-duty vehicles by

Research projects aimed at improving energy efficiency are being carried out in all transport modes, they include:

- more fuel-efficient engines for light-duty road vehicles
- innovative power trains for commercial vehicles that deliver power to the surface more efficiently, including engine and transmission technology
- emission-reduction technologies for diesel locomotives and marine engines
- clean and energy efficient marine diesel power trains
- electric ship technology, including electric propulsion technologies

The CO<sub>2</sub> reduction potential in maritime transport, as identified in the EU-funded project HERCULES,

Figure 4. CO<sub>2</sub> emissions from new cars 1995-2010



ACEA, 2012



is shown in Figure 5. Research contributes to the development of cleaner, more efficient technology in aviation.

The European Commission and the aviation industry are collaborating in the Clean Sky joint initiative. This initiative is directed towards greener air transport by optimising aircraft technology with, for instance, smart wings, more energy-efficient engines and aircraft design (eco-design). The Sustainable and Green Engine (SAGE) Integrated Technology demonstrator (ITD) of Clean Sky is dedicated to demonstrating engine technologies for all sectors of the civil aerospace market, including regional, narrow body and wide body fixed wing aircraft and rotorcraft.

The Advisory Council for Aeronautical Research in Europe (ACARE) has identified the following as being the main contributors to the achievement of the targeted 50% reduction in CO<sub>2</sub> emissions:

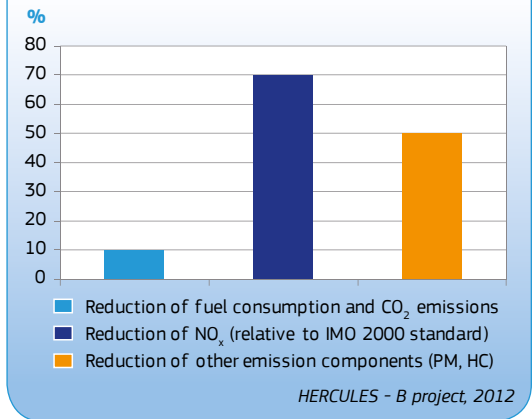
- Efficient aircraft: 20-25%
- Efficient engines: 15-20%
- Improved air traffic management: 5-10%

In the rail sector, EU funded research on improving energy efficiency is working on a range of options. These include innovative traction technologies, components and layouts, the development of rolling stock, and operation and infrastructure management strategies see the project Railenergy on page 13.

### Green Public Procurement

Green Public Procurement is a powerful market mover for the introduction of new technologies and stimulates procurement of energy-efficient and low-carbon vehicles. This initiative is directed to national, regional and local contracting authorities and contracting entities and operators of public transport services.

Figure 5. Potential of CO<sub>2</sub> and GHGs reduction from ship engine research



Directive 2009/33/EC on the Promotion of Clean and Energy Efficient Road Transport Vehicles (EC, 2009c) aims at stimulating broad market introduction of environmentally friendly vehicles. The Directive requires that energy and environmental impacts linked to vehicle operation be incorporated in purchase decisions. These lifetime impacts include vehicle energy consumption, CO<sub>2</sub> emissions, and emissions of the regulated pollutants of NO<sub>x</sub> (Nitrogen Oxide), NMHC (Non-Methane Hydrocarbon) and PM (particulate matter).

Implementation of the directive is supported by the Intelligent Energy Europe (IEE) programme to develop tools and techniques. For example, lifetime cost toolboxes have been developed to calculate fuel consumption, CO<sub>2</sub> emissions, and vehicle emissions under road operating conditions, based on simple on-board measurements.



## Railenergy

Energy efficiency solutions for railway rolling stock, rail infrastructure, and train operations

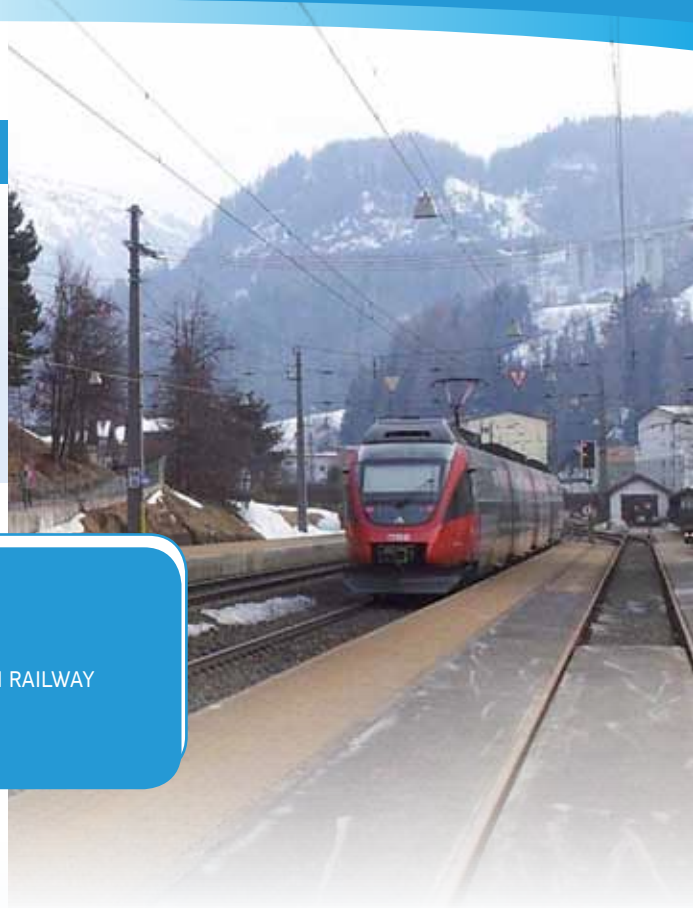
**Status:** Completed

**Total cost:** EUR 14 666 569

**EU contribution:** EUR 7 999 999

**Coordinator:** UNION OF EUROPEAN RAILWAY INDUSTRIES

**Website:** [www.railenergy.org](http://www.railenergy.org)



**Railenergy has demonstrated that promising new technologies are available to cut energy consumption by rail transport, with spin offs for reduction in CO<sub>2</sub> emission and life-cycle costs. The project demonstrated that the 6% energy reduction target for European railways by 2020 is achievable with the implementation of common technical standards, infrastructure management strategies, and traction technology measures that can also be applied to existing rolling stock.**

Funded under the Sixth Framework Programme, Railenergy brought together 27 European railway operators, infrastructure managers, component suppliers and consultancies in a sector-wide platform. Building on an integrated approach, the project generated new validation standards for the energy performance of rail products and services, and contributed to further harmonisation of the rail sector in the EU.

### BACKGROUND

Railways are highly energy efficient compared to other transport modes. This is mainly because

of low rolling and air resistance of locomotives, railcars and wagons running on dedicated tracks, and in a controlled, regulated driving pattern.

Energy consumption in the railway system is determined by the highly interrelated subsystems of rolling stock, infrastructure, signalling systems and circulation schemes. The Railenergy project adopted an integrated approach to identify technical and operational measures to increase the efficiency of planning, design, procurement and operation of the railway system. To quantify the impact of such measures, a detailed model was developed to forecast energy consumption

in the rail system. A baseline scenario up to 2020 was used as the benchmark in assessing technical and operational options for reducing energy consumption.

## RESULTS

Railenergy resulted in a series of technological and operational measures to improve energy efficiency in rail transport, with consequent impacts on CO<sub>2</sub> emission reduction.

### Toward EU technical standards

Railenergy facilitated production of the first joint 'Technical Recommendation on Specification and Verification of Energy Consumption for Railway Rolling Stock' (TecRec 100\_001) by the International Union of Railways and the European Rail Industry. This voluntary standard provides the framework for generating comparable energy performance values for trains and locomotives on a common basis and thus supporting benchmarking and improvement of the energy efficiency of rail vehicles.

### Energy efficiency calculator

Railenergy developed an energy efficiency calculator to establish the energy saving potential for suburban, regional, intercity and freight trains over their service life. This calculator is to be used in assessing energy efficiency strategies.

### Recommendations for operational measures

In-service and out-of-service measures were identified that result in high savings at relatively low costs compared to technological options. These operation measures include eco-driving procedures for all types of power supply, energy-efficient traffic management, and parked train management.

### Recommendations for technological measures

Promising technological measures for rolling stock include motor flux management, energy management of auxiliaries, and medium frequency energy distribution. Measures for diesel trains include permanent magnet motor technology and on-board energy storage systems. Most of these technologies can be applied during refits of existing rolling stock, even with a short service life.



## 5

## POLICY CONTEXT

# Use of alternative fuels and propulsion systems

**Extensive research and development has led to advanced technologies with the potential to replace fossil fuel driven vehicles with alternative fuels and propulsion systems to reduce energy consumption and CO<sub>2</sub> emissions. The stage has been reached where pilot projects are being implemented in each of the key transport modes.**

Alternative fuels refer to alternatives to gasoline and diesel. Advanced technologies are being explored to enable a sustainable shift from a fossil-driven to a decarbonised transport system. Promising alternative fuels are:

- electricity/hydrogen and biofuels (liquids) as options in all transport modes
- synthetic fuels as a bridge from fossil to biomass-based fuels
- methane (natural gas and biomethane) and Liquefied Petroleum Gas (LPG) gas complementary fuels

The extent and complexity of the CO<sub>2</sub> reduction challenge in transport require extensive R&I investment in the full scope of options. Under various EU programmes, research on alternative fuels ranges from fundamental research to market entry strategies. Demonstration projects on vehicle and infrastructure performance and safety are being carried out with a view to removing barriers to market entry in the key transport modes. These demonstration projects include vehicles powered with

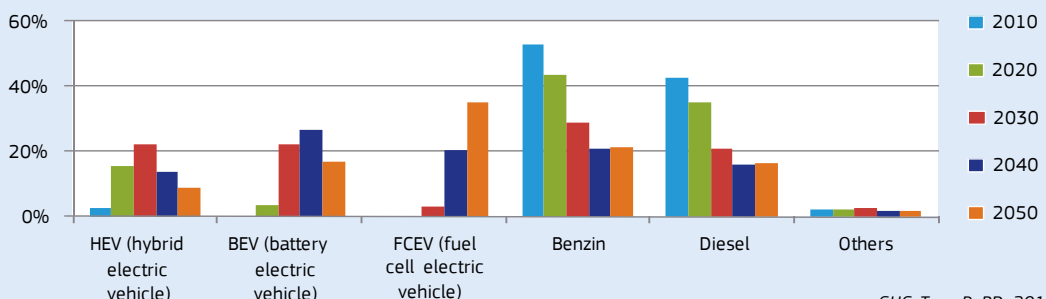
biofuels, hydrogen and fuel cells as well as battery electric and hybrid electric vehicles with plug-in technology.

## Road transport

Contributing about one-fifth of all CO<sub>2</sub> emissions in the EU, road transport is a primary target for research on alternative fuels. Biofuels are already on the market, either as admix or as self-contained fuel. Pilot projects are being carried out on other alternative fuels and propulsion systems, such as electricity. However, further R&I is needed to achieve commercial breakthroughs with these technologies.

Policies and strategies for CO<sub>2</sub> emission reduction have set targets for 2020 to increase the share of biofuels and of alternative hydrocarbon fuels. Targets have also been set for the development of hydrogen and fuel cell technology as economic, safe and reliable alternatives to fossil fuel. Research indicates promising applications for electric vehicles for short distances, hydrogen and

Figure 6. Market penetration of fuel and propulsion systems



methane for medium distances, and bio-fuels/synthetic fuels, LNG (Liquefied Natural Gas) and LPG for long distances to reduce CO<sub>2</sub> emissions from road transport. New concepts for freight transport based on electricity may change the logistics chain. The expected market penetration of alternative fuels and propulsion systems in road transport is presented in Figure 6 (see page 15).



#### *Short-distance journeys*

Most people in Europe live in urban areas and mainly travel short distances. Such journeys are estimated to account for 40% of all CO<sub>2</sub> emissions from road transport. The EU target for 2030 is to cut the number of fossil-fuelled vehicles in urban areas by half and to phase out these vehicles by 2050. CO<sub>2</sub>-free transport and logistics in large cities is the target for 2030.

Low emission requirements and their maximum range favour the development of electric vehicles especially for urban use. Increasing the share of renewable energy in electricity production would then have a direct impact on transport CO<sub>2</sub> emissions. Electrification of road transport and the introduction of electric vehicles are major components of the European Green Car Initiative. This public private partnership supports R&I on technologies and infrastructure for alternative energy sources.

#### *Medium to long-distance journeys*

On the path to low emission vehicles, vehicles fuelled with biodiesel or biogas show the greatest promise in the short term for medium and long-distance journeys. Second generation biofuels generated from biomass can reduce CO<sub>2</sub> emissions from road transport significantly. In the long term, new fuel and propulsion systems are needed to achieve the CO<sub>2</sub> emission reduction targets set for 2050. The Fuel Cell and Hydrogen initiative aims to accelerate the introduction of these two future-oriented technologies with the development of robust hydrogen supply and fuel cell technologies. Other alternatives will be explored in Horizon 2020.

## Rail transport

Railway services, including urban rail systems, run mainly on electricity, which will remain the major source of power for railways. Further electrification of rail tracks wherever feasible will contribute to CO<sub>2</sub> emission reduction as will the use of sustainable fuels for energy

generation. Power generation is on a path of decarbonisation through the 'Emission Trading System' and renewable energy targets also apply to railway services.

Where electrification is not feasible or economically viable — for instance in rural areas — the diesel engine is currently the only option. EU-funded research initiatives such as Railenergy are investigating advanced biofuels and innovative engine technology to reduce CO<sub>2</sub> emissions for non-electrified tracks. Research has led to the development of lower carbon technologies for diesel locomotives and rail vehicles including rail cars, light and heavy-haul locomotives, and hybrid technologies.

## Water transport

The challenging target for maritime transport is a 40% reduction in CO<sub>2</sub> emissions from maritime bunker fuels. Research covers a wide range of aspects, from testing biofuels as short-term alternatives to fossil fuel to battery-powered pilot vessels for the long-term. There are good prospects for synthetic and paraffinic fuels for all types of vessels. New ship designs and new engines based on the Energy Efficiency Design Index (EEDI) will influence CO<sub>2</sub> production. For inland waterways and small boats, hydrogen is a promising alternative, while LPG and LNG show potential for short sea shipping vessels, and LNG and nuclear power for maritime shipping.

## Air transport

Civil aviation produces 2 to 3% of transport CO<sub>2</sub> emissions. There is a target of 50% emission reduction per passenger-kilometre by 2020. Also, 40% of aviation services should operate on low carbon fuels by 2050.

The highest priority in aviation research is the development of greener engine technologies for market application, such as in the Clean Sky Joint Initiative. While aviation will continue to rely on liquid kerosene, promising sustainable alternatives to fossil kerosene are synthetic biomass-derived fuels and second generation biofuels. As a result of extensive research, biofuels were approved for use in 2011 and demonstration and commercial flights are now being carried out using add-on biofuels.



## TOSCA

Technical opportunities and strategies to climate friendly transport

**Status:** Completed  
**Total cost:** EUR 743 196  
**EU contribution:** EUR 743 196  
**Coordinator:** UNIVERSITY OF CAMBRIDGE  
**Website:** [www.toscaproject.org](http://www.toscaproject.org)



The TOSCA project identified technologies and alternative fuels to decrease energy use in all transport modes by 20 to 30% and thus to achieve a significant reduction in CO<sub>2</sub> and other greenhouse gas emissions. These technologies include plug-in hybrid vehicles, electric vehicles, and second generation biofuels. A further 5 to 20% energy reduction can be achieved with the deployment of intelligent transport systems. However, an uptake of new technologies requires further policy interventions to bring emission reduction closer to the 2050 targets.

### BACKGROUND

Funded under the Seventh Framework Programme, TOSCA assessed the strategic perspective of new transport technologies and fuels for reducing energy consumption and greenhouse gas emissions. To evaluate policy interventions to push these technologies and fuels in the market place, TOSCA assessed the technical feasibility and economic affordability of new technologies in road, rail, sea and air transport.

### RESULTS

#### Techno-economic assessment

A techno-economic assessment of all transport

modes and fuels demonstrated that promising technologies possibly available after 2020, such as stepwise electrification for power-trains, could reduce energy use and CO<sub>2</sub> emissions.

The most promising technologies in terms of emission reduction and cost effectiveness still require substantial R&I investment and potentially also new infrastructure. These technologies in the different transport modes include:

- light vehicles, electronically driven train (hybrids and battery electric), fuel-cell electronically driven train and biofuel technologies
- heavy trucks, reduced rolling resistance and F-T diesel (Fischer-Tropsch diesel)

- trains, combination technology and freight improvements
- aircraft, open rotor engines and F-T jet (Fischer-Tropsch jet)
- ships, air cavity system.

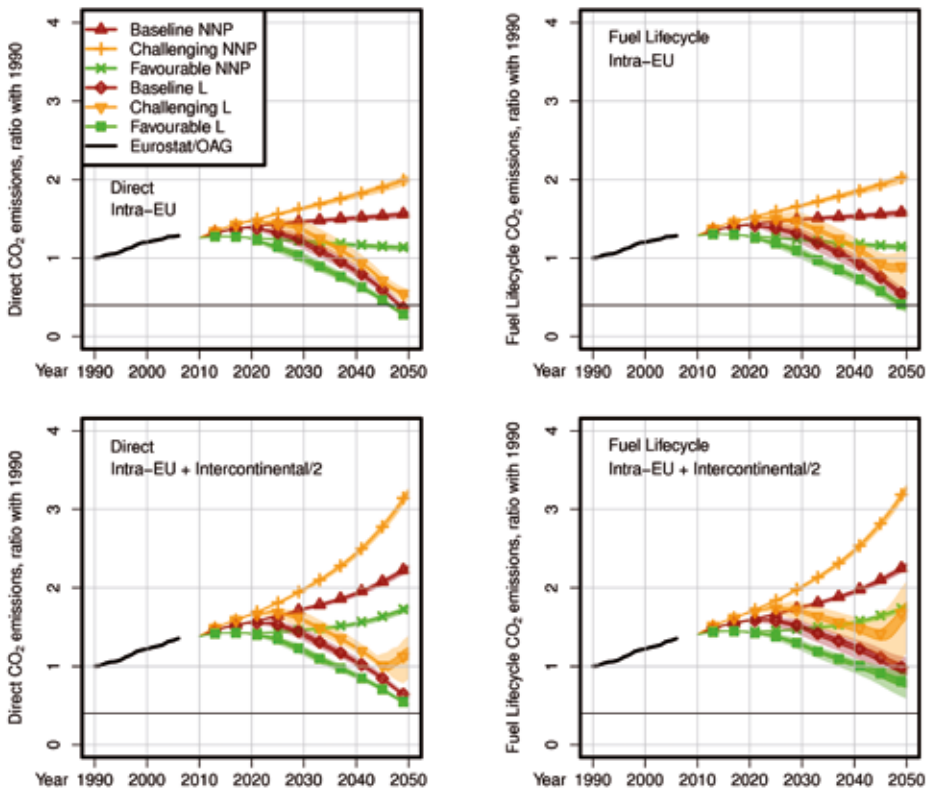
**Demand scenarios**

The impacts of these new technologies without additional policy interventions, such as regulatory measures, subsidies and tax incentives, were assessed in various transport demand scenarios. The results indicated that even under the most favourable scenario, reduction in greenhouse gas emission did not reach the targets set for 2050 (see Figure 7 CO<sub>2</sub> Emissions). This scenario assumed relatively low economic growth in the EU-27 (+0.7% GDP per year), relatively high oil prices (€54 to €144 per barrel in 2050) and electricity produced with less CO<sub>2</sub> emissions than under current practices (3% per year per unit of electricity production).

**Policy intervention**

With limited policy interventions (R&I, carbon tax and subsidies) a maximum emission reduction of 20% would be possible in 2050. TOSCA concluded that extensive R&I investment would be required to reduce direct emissions in 2050 by 11 to 13%, in addition to the above described result from policy interventions. In combination with a carbon tax (0.5 to 0.8% of GDP in 2050) this latter percentage reduction could increase 18 to 25%. R&I combined with a subsidy scheme would promote the uptake of alternative-fuelled vehicles and reduce direct emissions by 20 to 30% in 2050. However, emission reduction would come closer to 1990 levels if there were an increased R&I investment (2% of GDP) together with a mix of subsidies and taxes as well as the potential for biofuel imports (see Figure 7).

Figure 7. CO<sub>2</sub> Emissions



TOSCA project, 2010



## WHAT'S NEXT?

# Policy and Research outlook

Research and Innovation has contributed to developing targets for CO<sub>2</sub> emission reduction set out in the 2011 White Paper on Transport. In implementing these policies, continued R&I is essential in developing and supporting advanced technologies and innovative solutions needed to reduce the transport sector's oil dependency, and to curb environmental and social impacts. R&I efforts towards a low carbon transport system are vital to the EU objective of transforming European transport into a modern, resource-efficient and safe system.

To help prioritise and focus EU policy in transport research, innovation and deployment, the Commission is preparing a Strategic Transport Technology Plan (STTP). The plan will set out a comprehensive long-term approach (2035-2050) in which new technologies are placed in a social, environmental, and institutional context. The emphasis will be on the deployment of leading-edge technologies. R&I and market entry roadmaps will be prepared for various technologies to cover the entire innovation chain from fundamental research to market entry. The plan will identify related policy, and financial and organisational elements required for sustainable implementation

of innovative solutions. In collaboration with sector stakeholders and the Member States, the STTP will be used to facilitate coordination of public and private research and innovation efforts across Europe.

In parallel with the preparation of the STTP, the Common Strategic Framework for Research and Innovation (Horizon 2020) has been prepared and adopted by the European Commission. Horizon 2020 is aligned with the EU policy objectives set out in the White Paper on Transport and identifies development and operation of smart, green and integrated transport as a priority societal challenge.

Closer cooperation and interaction between EU, national and regional research programmes and initiatives is essential in increasing the efficiency of research investments. This is necessary to prevent duplication and to achieve the critical mass required for breakthrough technological innovations to support targets for a low carbon transport system. Moreover, information exchange in transport R&I with countries outside the EU needs to be fostered and extended in tackling issues in decarbonising transport on a global scale.



# Bibliography

- ACEA (2012): European Automobile Manufacturers' association, Key figures, Trends in new cars characteristics, <http://www.acea.be/collection/statistics/>
- CIVITAS METEOR (2006): CIVITAS 1 Cross site Evaluation, METEOR Deliverable 6, METEOR consortium, Rijswijk.
- European Commission (2009a): Communication from the Commission, A sustainable future for transport: Towards an integrated, technology-led and user friendly system, COM(2009) 279 final, Brussels.
- European Commission (2009b): Regulation (EC) No 43/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO<sub>2</sub> emissions from light-duty vehicles, Official Journal of the European Union, L 140/1
- European Commission (2009c): Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of clean and energy-efficient road transport vehicles, Official Journal of the European Union, L 120/5
- European Commission (2010): Decision No 661/2010/EU of the European Parliament and of the Council of 7 July 2010 on Union Guidelines for the Development of the Trans-European Transport Network, Official Journal of the European Union, L 204/1.
- European Commission (2011): White Paper, Roadmap to a Single European Transport Area, Towards a competitive and resource efficient transport system, COM(2011) 144 final, Brussels.
- European Commission (2011a): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Energy Roadmap 2050, COM(2011) 885 final, Brussels.
- European Commission (2011b): Proposal for a Regulation of the European Parliament and of the Council, establishing Horizon 2020 – The Framework Programme for Research and Innovation, COM (2011) 809 final, Brussels.
- European Commission, Directorate – General for Climate Action (2010a): The Climate and Energy Package, [http://ec.europa.eu/clima/policies/package/index\\_en.htm](http://ec.europa.eu/clima/policies/package/index_en.htm)
- European Commission, Directorate – General for Climate Action (2010b): Reducing Emissions from transport, [http://ec.europa.eu/clima/policies/transport/index\\_en.htm](http://ec.europa.eu/clima/policies/transport/index_en.htm)
- European Commission, Directorate-General for Energy and Transport (2007): Impact Assessment on a new approach for the cleaner and more efficient vehicles directive proposal, edited by PWC, Final Report.
- European Commission, Directorate-General for Energy and Transport (2008): European Energy and Transport Trends to 2030 – Update 2007, Office for Official Publications of the European Communities, Luxembourg.
- European Green Cars Initiative (2012): Public-Private Partnership European Green Cars Initiative, <http://www.green-cars-initiative.eu>.
- European Fuel Cell and Hydrogen Initiative: Public – Private Partnership European Fuel Cell and Hydrogen Initiative, <http://www.fch-ju.eu>
- European Clean Sky Initiative: Public – Private Partnership Clean Sky, <http://www.cleansky.eu/>
- FREIGHTWISE (2008): EU FP6 project, Framework for Intelligent Intermodal Transport, <http://www.freightwise.info/cms/>
- GHG-TransPoRD (2012): EU FP7 project, Reducing greenhouse-gas emissions of transport beyond 2020: linking R&D, transport policies and reduction targets , <http://www.ghg-transpord.eu/ghg-transpord/index.php>
- HERCULES – B project (2012): Higher – Efficiency engine with ultra – low emissions for ship, <http://www.hercules-b.com>
- Railenergy (2010): EU FP6 project, Innovative Integrated Energy Efficiency Solutions for Railway Rolling Stock, Rail Infrastructure and Train Operation, <http://www.railenergy.org/>
- TOSCA (2009): EU FP7 project, Technology Opportunities and Strategies Toward Climate-Friendly Transport, <http://www.toscaproject.org/>
- Transport for London "Case study London Congestion Charging": <http://www.tfl.gov.uk/roadusers/congestioncharging/>
- United Nations (1998): Kyoto Protocol to the United Nations Framework Convention on Climate Change.

# Glossary

ACARE	Advisory Council for Aeronautical Research in Europe
CARS21	Competitive Automotive Regulatory System for the 21st Century
CIVITAS	Clean and Better Transport in Cities
CO <sub>2</sub>	Carbon dioxide
CORDIS	Community Research and Development Information Service
COST	European Cooperation in Science and Technology
EC	European Commission
EEDI	Energy Efficiency Design Index
ECCP	European Climate Change Programme
ERA-NET	Framework for coordination of research activities
ERTMS	European Rail Traffic Management System
ETS	Emission Trading Scheme
EU	European Union
F-T DIESEL	Fischer-Tropsch diesel
F-T JET	Fischer-Tropsch jet
GDP	Gross Domestic Product
ICT	Information and Communication Technologies
IEE	Intelligent Energy Europe
IT	Information Technologies
ITD	Integrated Technology Demonstrator
ITS	Intelligent Transport Systems
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NMHC	Non-Methane Hydrocarbon
NO <sub>x</sub>	Nitrogen Oxide
PM	Particulate matter
R&I	Research and Innovation
RIS	River Information Services
SAGE	Sustainable and Green Engine
SESAR	Single European Sky Air Traffic Management Research
SMEs	Small and medium enterprises
STTP	Strategic Transport Technology Plan
SUMPs	Sustainable Urban Mobility Plans
TEN-T	Trans-European Transport Network
TRIP	Transport Research and Innovation Portal
TRKC	Transport Research Knowledge Centre



The ambitious target of 60% reduction in greenhouse gas emissions by 2050 requires transformation of the transport system in Europe. Decarbonising transport calls for the use of less and cleaner energy, and more efficient use of modern transport infrastructure and services. These strategic targets in EU policy are supported by substantial investment in research to develop innovative and sustainable solutions in efficient use of transport infrastructure and services, more energy-efficient transport, and use of alternative fuels and propulsion systems. This Policy Brochure, which is produced by the Transport Research and Innovation Portal (TRIP), highlights the contribution of research and innovation in meeting the EU targets on CO<sub>2</sub> emission reduction in the transport system.

**[www.transport-research.info](http://www.transport-research.info)**

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